A Client/Server Approach To Telemedicine

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ABSTRACT

This paper describes the Medical College of Ohio's efforts in developing a client/server telemedicine system. Telemedicine vastly improves the ability of a medical center physician or specialist to interactively consult with a physician at a remote health care facility. The patient receives attention more quickly, he and his family do not need to travel long distances to obtain specialists' services, and the primary care physician can be involved in diagnosis and developing a treatment program [1, 2]. Telemedicine consultations are designed to improve access to health services in underserved urban and rural communities and reduce isolation of rural practitioners [3].

This telemedicine system is based on the client/server model using a graphical browser as the user interface. Two communication techniques are being deployed simultaneously: synchronous and asynchronous communication. Synchronous communication uses interactive videoconferencing, while asynchronous communication uses a store-and-forward procedure to electronically transport the telemedicine computerized patient record (CPR) between the primary and consulting physicians. The software supports multipoint data sharing, point-to-point video and audio conferencing, transmission of diagnostic images and patient data from remote locations to medical specialists, electronic mail, and access to the Internet.

INTRODUCTION

The mission of the Medical College Hospitals (MCH) is to provide superior patient care which is compassionate and cost effective, and to support and enhance the health education mission of the Medical College of Ohio (MCO). In partnership with the College, the Hospitals continuously strive to develop and incorporate advancements in health care knowledge to improve the quality of patient care. It is this mission statement that lead the Medical College of Ohio towards investigating the capabilities of telemedicine.

Our nation is currently experiencing a shift towards decreasing the number of physician specialists and increasing the number of primary care physicians. In addition, the model for health care delivery is migrating towards an emphasis in primary care, wellness programs, and the treatment of patients in the region in which they reside. This health care delivery model strives to treat the patient in the field rather than the traditional hospital setting. In order to achieve this goal and still maintain the quality of care expected from the health care delivery model, new methods of delivery will need to be developed [4]. Telemedicine may be the answer to this shift in health care delivery in order to maintain and improve access to physician specialists [5].

The traditional methods of conducting a consultation include the use of the telephone and fax machines. These technologies take a step backwards in that information that was previously digital and understood by a computer is transformed into a format which is no longer computer readable [6]. This means that the recipient of the information can not manipulate the information in any way. In addition, fax technology is not adequate for transmission of many types of medical data, such as x-ray films, echocardiograms and ultrasounds. Telemedicine addresses these problems by allowing digital information to remain in a digital format.

CLIENT/SERVER MODEL

The MCO telemedicine system is based on using a client/server model. In the client/server model, one process is the server, and one or more processes are clients. The server process provides a particular service to the client processes. The server listens for requests for service at a well-known address, and the clients use this same address to send requests for service to the server [7].

The design of this system places a server at each rural and urban site in northwest Ohio. Urban sites are included because there is a need for medical care and the sites can be served by telemedicine with equal utility. The telemedicine servers function as the heart of the communication system for the region. The servers are used to maintain the telemedicine CPR, communicate

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between the referring primary care physicians and the consulting specialists, and transmit medical data between telemedicine locations.

The current pilot system is being deployed on UNIX servers. The long-range plans include multiple servers dispersed among medical departments accessible from various locations through Macintosh and PC clients. A physician will be able to access the telemedicine consultation records for his patients from his office computer.

Network Infrastructure

The telemedicine network is designed around a switched T1 private network which can carry long distance telephone traffic when the lines are not being used for telemedicine. This dual use of bandwidth will help defray the cost of the network by reducing long distance telephone expenses. A diagram of the telemedicine network is shown in Figure 1.

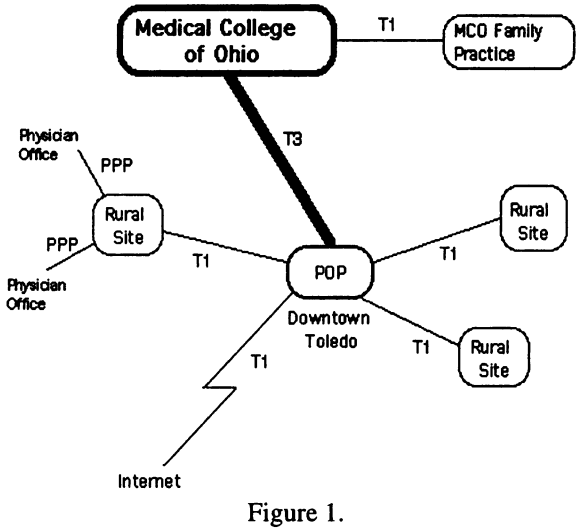

Figure 1.

The center of this private network is a Point-of-Presence (POP) located in downtown Toledo. Each rural and urban site is connected to the network at this POP by a leased T1 line. A higher bandwidth (T3) line runs from the POP to the Medical College of Ohio. Telemedicine consultation records traveling on this private network are encrypted to preserve security and patient confidentiality.

INTERNET ACCESS

One of the selling points of this telemedicine system is that it provides the remote site with access to the Internet. The Internet is a worldwide network connecting thousands of private and regional networks together from all over the world. Connections to the Internet exist in virtually every country encircling the globe. In fact, the term "Information Superhighway" has been used recently in reference to the Internet.

The World Wide Web (WWW) is a networked hypertext system developed by CERN European Laboratory for Particle Physics in Geneva that can run on the Internet [8]. The Internet provides access to a worldwide collection of information resources and services. These resources can be on-line databases such as Medline, medical case histories, educational material, software, WWW documents, as well as many other types of resources. WWW documents consist of text, images, sound, video sequences, and hypertext links to other documents.

Graphical Browser

Netscape was chosen as the graphical user interface for the telemedicine pilot system and the WWW. Netscape allows users to navigate through the Internet using a point-and-click interface. The physician can not only access the resources provided as part of the telemedicine system, but can also access any other WWW server on the Internet by using Netscape. The telemedicine home page is shown in Figure 2. In order to assist the physician in browsing the Internet, a page of links to other medical sites is included in the telemedicine system. The novice user can use these sites as starting points for exploring the Internet, while the more experienced Internet user is not prevented from typing in a Uniform Resource Locator (URL) and going wherever he chooses.

Since one of the goals of the Medical College of Ohio telemedicine system is to provide universal access to libraries, databases, electronic mail as well as to provide the capability of performing telemedicine consultations, the widely available and versatile interface of Netscape seemed to be an ideal choice. The benefit of using this graphical user interface is that once the physician learns how to use the telemedicine system, he will also be able to access the Internet, Medline (via OhioLINK), and other databases using the same equipment and skill sets [9].

TELECONFERENCING

The ability to teleconference in real-time makes up the synchronous communications portion of the system. Videoconferencing systems referenced in most of the published articles on telemedicine systems achieve full screen, close to full motion video using compression technology, and can be used on moderate or high speed telephone lines for communication. The strength of

these systems is the interactive nature which allows real-time interviews between patients and physicians including full screen images of medical data [10].

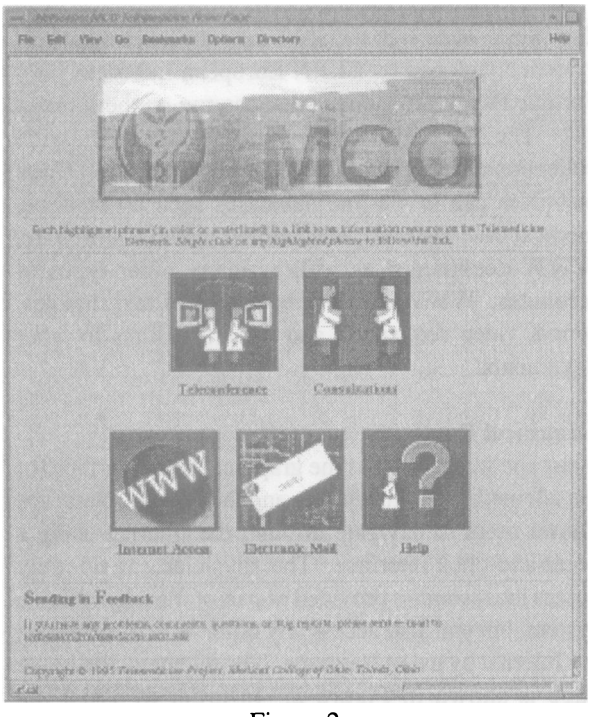

Figure 2.

Teleconferencing in the telemedicine system is currently accomplished by launching a third-party product called InPerson from Netscape. InPerson is a multimedia desktop conferencing tool for Silicon Graphics, Inc. (SGI) workstations such as the Indy, Indigo, and Indigo2. InPerson was developed by SGI and can use either proprietary compression techniques or H.261 low-bandwidth compression algorithm [11].

A teleconference can include multiple parties, with audio and video, shared whiteboard, and use of a shared shelf for file sharing. The whiteboard can have an unlimited number of pages with each participant being able to determine what page other participants are currently viewing. InPerson allows viewing of 2D images as well as 3D models, where all participants can rotate and size the models. In addition, annotations made by one participant are displayed in real-time for all other participants.

A teleconference is begun by clicking on the teleconference button on the home page within Netscape. This links to a page that asks the physician to select a person to call and a patient to discuss from the list of consultation patients then click on a button labeled "Begin Teleconference". After clicking on the "Begin Teleconference" button, InPerson is launched causing a phone icon to appear on the desktop. Shortly after the phone appears, the teleconference call is automatically placed to the person selected from the Netscape page. The physician at the remote site goes through a similar preparation procedure except that once the phone icon is on the desktop, he simply waits for the phone to ring and then answers the call by clicking on the phone. The teleconference starts when the remote site clicks on the phone to answer the incoming call. Figure 3 is an example of a teleconferencing session.

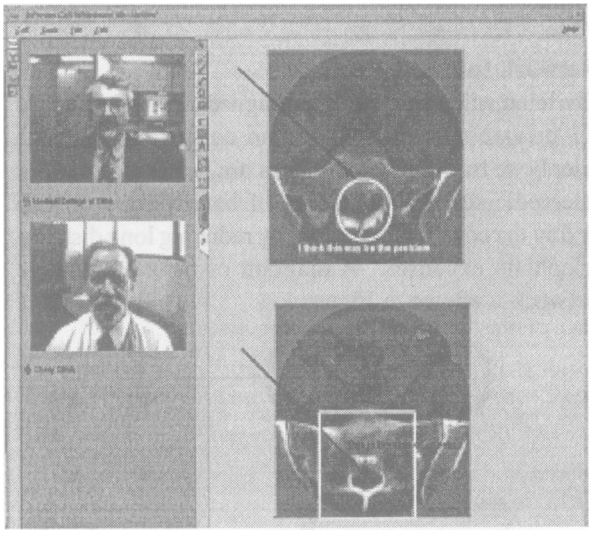

Figure 3.

InPerson has many advanced features for controlling the teleconference, such as selecting the size of the video windows, freezing the video window for better response time, etc. InPerson also has sophisticated algorithms that monitor network congestion and dynamically adjust the video settings (frame rate or video quality) so as to not overwhelm the network.

Our view of the synchronous communications portion of the system is that it is most effective when used physician to physician rather than in examining the patient on-line. The video rate and resolution available using InPerson is not sufficient to be used for remote physical examination. However, still images of the patient can be captured using the SGI workstation Indy Cam and placed on the shared whiteboard for discussion as an effective use of the technology. Other medical devices can also be attached to the workstation during a teleconference, such as a dermascope or electronic stethoscope.

CONSULTATIONS

The ability to consult off-line makes up the asynchronous communications portion of the system.

Off-line telemedicine consultations are implemented using a store-and-forward procedure to electronically transport the telemedicine consultation record and medical data between the referring and consulting physicians [12].

We believe that the delivery of telemedicine is really a medical data problem and only secondarily an interactive interviewing problem. Current videoconferencing systems handle data poorly. Therefore, the technology being used in most telemedicine systems today actually does not effectively handle the most important aspect of telemedicine, namely medical data.

The consultation portion of this system addresses this problem by allowing physicians to share medical data electronically. The telemedicine CPR, or consultation record, contains all medical data relevant to the telemedicine consultation and constitutes a shared medical record for the referring and consulting physician in discussing an on-going case.

A telemedicine consultation record can only be accessed by the referring and consulting physicians. A physician must sign-on to the telemedicine system. Once successfully signed on, the Consultation button can be selected from the Home Page. The Consultation Page presents him with an up-to-date list of his consultations. The consultations are divided into four categories: Created, New, In Progress, and Completed.

The referring physician creates a new telemedicine consultation record at his site. He has the ability to add textual or audio annotations to any field in the consultation record. The referring physician enters the patient demographics, description of the patient's medical history, and patient's observed conditions. This record is then transferred electronically to the consulting physician.

The consulting physician checks if there are any new consultations by reviewing the list in the New category. The physician can read the textual information and listen to any audio annotations contained in the patient's consultation record. He then determines a course of action and enters that information into the Tests Specified section of the consultation record. This consultation record is transferred electronically to the referring physician's site. The patient's consultation record is now shown under the In Progress category list at each server location.

The referring physician reviews the updated consultation record, then proceeds to perform the requested tests at his facility. The test data is collected into the patient's consultation record and electronically transported back to the consulting physician.

The consulting physician reviews the results in the patient's consultation record and formulates his interpretations and treatment plan. The consulting physician's interpretations and treatment plan are sent back to the referring physician, as shown in figure 4.

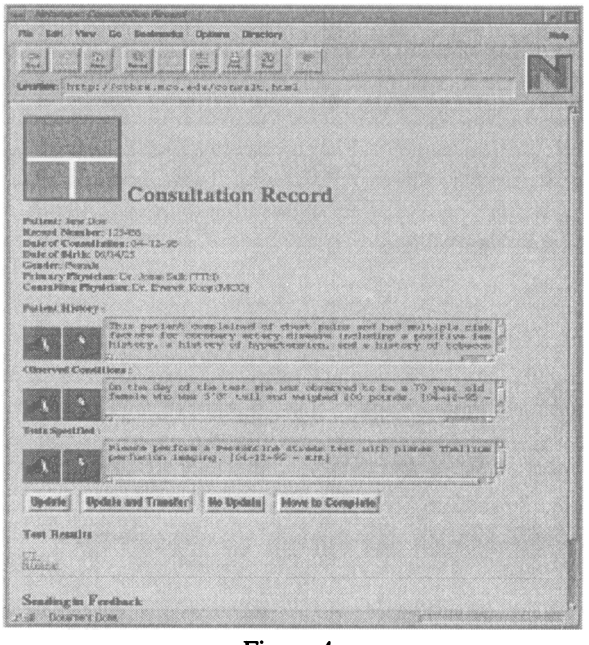

Figure 4.

The referring and consulting physician now each possess a copy of the entire telemedicine consultation record. Together they determine whether any other procedures are necessary or decide to complete the telemedicine consultation. Only the referring physician can complete a consultation. The patient's consultation record is stored in the Completed list for future reference.

Our view of the asynchronous portion of the telemedicine system is that it addresses many of the difficulties associated with traditional methods of consultations, such as physician availability and access to medical data. This store-and-forward method allows the consulting and referring physicians to interact more efficiently by having access to their patient's current consultation 24 hours a day, seven days a week.

ELECTRONIC MAIL

Electronic mail is also supported by the telemedicine system. Electronic mail enhances communications

between sites for matters outside the consultation process. An electronic mail message can be composed through the Netscape interface or through a third-party application called Z-Mail. Netscape does not provide a method to read electronic mail through its graphical browser. Therefore, the telemedicine system uses Z-Mail as its electronic mail reader.

Z-Mail was selected for its ability to provide advanced capabilities through Multipurpose Internet Mail Extensions (MIME) compliance across most major platforms. Z-Mail enables you to send and receive mail attachments. An attachment is a separate file associated with a message [13]. Electronic mail attachments can be text files, graphics, images, sound files, or video [14]. This provides the physician with the ability to send a voice electronic mail message rather than requiring that the message be typed.

SUMMARY

In summary, the Medical College of Ohio telemedicine network unites the participating institutions and health care providers by providing tools to improve communications through the use of interactive teleconferencing, off-line consultations, access to the Internet, and electronic mail by utilizing an easy-to-use graphical interface. This client/server approach has the ability to provide cost-effective, superior patient care and support the health education mission of MCO.

Excerpts from this paper are available at http://www.mco.edu/iarc/telemed.html. To learn more about the Medical College of Ohio, check out our web site at http://www.mco.edu.

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